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Authors	Yi Wen
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By Force of Demand: Explaining International Comovements

Yi Wen*
Research Department
Federal Reserve Bank of St. Louis
yi.wen@stls.frb.org

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Abstract

This paper explores the possibility that economic fluctuations may be largely demand-driven. It is shown that the stylized open-economy business cycle regularities documented by Feldstein and Horioka (1980) and Backus, Kehoe and Kydland (1992) can be explained by demand shocks alone even in a standard general equilibrium model. Frictions such as market incompleteness, increasing returns to scale, and sticky prices do not appear to be the preconditions for resolving these long-standing puzzles.

Keywords: International Business Cycle, International Comovements, Demand Shocks, Saving-Investment Puzzle, Feldstein-Horioka Puzzle, Productivity, Labor Hoarding, Capacity Utilization.

JEL: E13, E20, E32.

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1 Introduction

One of the most salient features of the business cycle, as argued by Lucas (1977), is the persistent and positive comovements in aggregate economic activities, such as consumption, hours, productivity, investment, and output over the business cycle. The real business cycle (RBC) theory introduced by Kydland and Prescott (1982) and Long and Plosser (1983) has so far accounted for such comovements by relying heavily on technology shocks. Demand shocks have not played a major role in RBC models. The heavy reliance of standard RBC models on technology shocks to explain the business cycle, however, has been met by much criticism (see, for example, Blanchard 1989 and 1993, Cochrane 1994, Evans 1992, Gordon 1993, Mankiw 1989 and Summers 1986). More recently, Gali (1999, 2004) and Gali and Rabanal (2004) point out that the U.S. and European employment and productivity data are inconsistent with the implications of a standard RBC model driven by technology shocks.[1]

Economic activities are also highly synchronized across countries. Productivity, output, employment, consumption, and investment, for example, are positively correlated between the U.S. and Europe. But Backus, Kehoe, and Kydland (1992) show that standard general equilibrium models driven by technology shocks cannot explain such international comovements. Under free trade, standard models predict high activity in high-productivity countries and low activity in low-productivity countries, suggesting negative cross-country correlations for economic activities under country-specific technology shocks. Although introducing market frictions that inhibit free trade can mitigate the problems, some of the puzzles are highly robust to model modifications. For example, one of the most robust puzzles is that the predicted cross-country correlations are higher for consumption and productivity than for output, while the opposite is true in the data.[2]

This paper provides a plausible alternative to resolve the international business cycle puzzles without resorting to market frictions. It shows that the observed international synchronization in economic activities can be rationalized by standard general equilibrium theory once aggregate demand (in particular, consumption demand) is allowed to be the primary source of aggregate fluctuations. The standard two-country general equilibrium model of Backus, Kehoe, and Kydland (1992), for example, can predict both within-country and cross-country business cycle comovements when the main source of uncertainty is from consumption demand. In particular, the model can

[1] Based on this, they call into question the relevance of RBC theory for understanding economic fluctuations. This paper shows such a conclusion to be premature. On the other hand, Chari, Kehoe, and McGrattan (2001) also argue that Gali's findings are not robust.

[2] Many counter-factual predictions of the general equilibrium theory under technology shocks tend to be quite robust to model modifications. A vast literature has developed to address the issue. See, for example, Backus, Kehoe, and Kydland (1992, 1995), Baxter and Crucini (1995), Stockman and Tesar (1995), Kehoe and Perri (2002), Kollmann (2001), Baxter and Farr (2005), and Pakko (1997, 2003), to name just a few. For additional literature, also see Obtsfeld and Rogoff (2000), Chari, Kehoe, and McGrattan (2001), Heathcote and Perri (2002), and Xiao (2004), among others.

predict that: 1) national output, investment, productivity, and hours are positively correlated with their counterparts in other countries, and the cross-country correlations are stronger for output than for consumption and productivity (Backus, Kehoe, and Kydland, 1992 and 1995); 2) national saving rates and national investment rates are strongly positively correlated within each country (Feldstein and Horioka, 1980); and 3) the net-exports-to-output ratio is less volatile than output and is negatively correlated with output (Backus, Kehoe, and Kydland, 1992). Besides being able to predict the positive comovements of economic activities across nations, the model can also explain many key features of the domestic business cycle comovements which are thought explainable only by technology shocks, such as: 1) domestic productivity, employment, consumption, and investment are positively correlated with output over the business cycle (Kydland and Prescott, 1982); and 2) changes in output are more volatile than changes in consumption, but less volatile than changes in investment (Kydland and Prescott, 1982).[3]

The intuition for consumption demand shocks being capable of explaining international business cycle comovements is simple. Consider a standard two-country, one-sector stochastic growth model driven by exogenous shocks to the marginal utility of consumption. An increase in consumption demand in the home country raises aggregate demand for goods in the world, causing a "spillover" demand effect on other countries. Production and employment therefore increase both at home and abroad, resulting in their positive comovement across borders. Investment in both countries must also increase if the change in consumption demand is persistent, leading to increases in production capacities both at home and abroad so as to meet the anticipated rise in world demand. Since preference shocks are likely to be country-specific, consumption expenditures are less synchronized across countries than production. Consequently, standard general equilibrium theory predicts higher cross-country correlations for output than for consumption, as well as positive cross-country correlations for both employment and investment. Since the fluctuations are demand-driven, not technology-driven, there is little incentive for countries to shift capital across borders to meet the increased world demand (even under the assumption of perfect capital mobility) when a higher demand for output in one country also raises the demand for output in other countries. Consequently, national saving rates rise mainly due to the increases in national investment rates, not to changes in net exports. Hence predicted national savings and national investment are positively correlated even if capital is perfectly mobile across borders, giving rise to the apparent "home-bias puzzle" in international capital allocation (Feldstein and Horioka, 1980). Furthermore, if there are employment adjustment costs to induce labor hoarding behavior, productivity will also be procyclical and highly correlated across countries under country-specific demand shocks. Thus the observed posi-

[3] There is a literature arguing that demand shocks combined with market failures such as externalities are responsible for economic fluctuations. See, for example, Benhabib and Wen (2004), Farmer (1999), Wen (1998), Weder (2001), and Xiao (2004). However, I show in this paper that market failures such as externalities are not preconditions for explaining domestic and international comovements, although they may exacerbate the effects of demand shocks.

tive cross-country comovements in productivity can also be rationalized by demand shocks alone – without resorting to technology shocks or increasing returns to scale.

The importance of consumption demand shocks in helping resolve business cycle puzzles has been emphasized in the literature by a number of people. Important works include Baxter and King (1991), Stockman and Tesar (1995), Hall (1997), and Wen (2004), among others. Baxter and King (1991) show that preference shocks that create urges to consume can explain closed-economy business cycles almost as well as technology shocks provided that there are high enough increasing returns to scale in the economy due to externalities. Stockman and Tesar (1995) show that taste shocks in conjunction with technology shocks can help resolve some of the international comovement puzzles. However, since technology shocks play a major role in their analysis while taste shocks play only a minor one, Stockmand and Tesar do not resolve the puzzle of cross-country correlations being significantly higher for output than for consumption. Hall (1997) argues that in order to explain the labor market dynamics, preference shocks must dominate technology shocks in a standard closed-economy RBC model. Wen (2004) shows that preference shocks alone, without increasing returns to scale, are able to generate procyclical labor productivity under labor hoarding and variable capacity utilization. Wen (2004), however, does not address the international comovement puzzles. The novel contribution of this paper is to show that if preference shocks to consumption demand are given a dominant role, then many international business cycle puzzles can be resolved qualitatively even without market frictions, such as externalities, increasing returns to scale, imperfect competition, incomplete financial markets, imperfect risk sharing, sticky prices, and so on. These frictions may exacerbate the effects of demand shocks, but they are not preconditions for demand shocks to explain the qualitative features of the business cycle.

The finding that procyclical productivity in a country can be explained by either domestic demand shocks or foreign demand shocks (via net exports) helps in understanding and predicting the strong revival of the Japanese economy in recent years due to the strong export demand from China. This view of the procyclical productivity is consistent with traditional Keynesian theory, yet without needing to assume sticky prices.

The rest of the paper is organized as follows. A simple benchmark model is studied in Section 2 to gain intuition. A more general model is studied in Section 3. Finally, Section 4 concludes the paper with remarks for further research.

2 The Basic Model

This is a simplified version of the two-country model studied by Backus, Kehoe and Kydland (1992). The theoretical world economy consists of two identical countries, each represented by a large number of identical consumers and an identical production technology. The countries produce the same good and have the same preferences. The labor input in each country consists only of domestic labor, and consumption is subject to country-specific shocks.

In the home (h) and foreign (f) countries, the representative consumer maximizes the expected utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln(c_t^j - \Delta_t^j) - a \frac{\left(n_t^j\right)^{1+\gamma}}{1+\gamma} \right\}, \quad \text{for } j = h, f, \tag{1}$$

where c is consumption of the produced good, n is labor supply, and Δ represents a country-specific random shock to the marginal utility of consumption. Production of the single good takes place in each country according to the constant-returns-to-scale technology

$$y_t^j = \left(k_t^j\right)^{\alpha} \left(n_t^j\right)^{1-\alpha}, \quad \text{for } j = h, f. \tag{2}$$

World output from the two processes, $y_t^h + y_t^f$, is allocated to consumption and fixed investment:

$$\sum_j \left[c_t^j + k_{t+1}^j - (1-\delta)k_t^j\right] = \sum_j \left(k_t^j\right)^{\alpha} \left(n_t^j\right)^{1-\alpha}. \tag{3}$$

Net exports are given by $nx_t^j = y_t^j - \left[c_t^j + k_{t+1}^j - (1-\delta)k_t^j\right]$.

By exploiting the equivalence between competitive equilibria and Pareto optima, an equilibrium in this world economy can be computed as the solution to a planning problem of the following form:

$$\max_{\{c_t^j, n_t^j, \tau_t^j, K_{t+1}\}_{t=0}^{\infty}} \sum_j \left\{ E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln(c_t^j - \Delta_t^j) - a \frac{\left(n_t^j\right)^{1+\gamma}}{1+\gamma} \right\} \right\} \tag{4}$$

subject to

$$\sum_j c_t^j + [K_{t+1} - (1-\delta)K_t] \leq \sum_j \left(\tau_t^j K_t\right)^{\alpha} \left(n_t^j\right)^{1-\alpha}, \tag{5}$$

$$\sum_j \tau_t^j \leq 1, \tag{6}$$

and $K_0 > 0$ given for $j = h, f$; where K denotes the world capital stock, and $\tau^j \in [0,1]$ denotes the fraction of the world capital stock allocated to production in country j. Without loss of generality, an equal weight is assumed in the objective function.

The first-order conditions for $\left\{c^j, n^j, \tau^j, K\right\}$ are given respectively by:

$$\frac{1}{c_t^j - \Delta_t^j} = \lambda_t, \tag{7}$$

$$a\left(n_t^j\right)^{\gamma} = (1-\alpha)\lambda_t \left(\tau_t^j K_t\right)^{\alpha} \left(n_t^j\right)^{-\alpha}, \tag{8}$$

$$\alpha\left(\tau_t^j\right)^{\alpha-1} K_t^{\alpha} \left(n_t^j\right)^{1-\alpha} = \mu_t, \tag{9}$$

$$\lambda_t = \beta E_t \lambda_{t+1} \left[\sum_j \alpha \left(\tau_{t+1}^j\right)^{\alpha} K_{t+1}^{\alpha-1} \left(n_{t+1}^j\right)^{1-\alpha} + (1-\delta)\right], \tag{10}$$

where $\{\lambda, \mu\}$ are Lagrange multipliers associated with the world-wide resource constraints (5) and (6), respectively. The resource constraints support international risk sharing via three channels of cross-country transfers: transfer of consumption goods, transfer of investment goods, and transfer of fixed assets (i.e., factors of production). Equation (7) shows that the (expected) marginal utilities of current consumption are equalized across countries due to the transfer of consumption goods. Equation (8) is the labor-market equilibrium condition for each country. Equation (9) shows that the marginal products of capital are equalized across countries due to the transfer of fixed assets (capital mobility). Equation (10) equates the marginal cost of current savings to the expected marginal returns to investment in the world capital market due to the transfer of investment goods. Due to the international transfers of capital and investment goods, capital used in production in a specific country is not necessarily owned by residents of that country; thus, gross investment in a specific country (j) can be defined as

$$\begin{aligned} i_t^j &= \pi^j K_{t+1} - (1-\delta)\pi^j K_t + (\tau_t^j - \pi^j) K_t \\ &= \pi^j I_t + (\tau_t^j - \pi^j) K_t, \end{aligned}$$

where I_t denotes aggregate world investment, and π^j ($= 0.5$) denotes the fraction of the world population residing in country j, which is also the steady state value for τ_t^j. The last term in the above expression for national investment, $(\tau_t^j - \pi^j)K_t$, indicates the size of foreign capital operating in country j during period t, and is called foreign direct investment.[4] Foreign direct investment for country j is positive if $\tau^j > \pi^j$ and negative if $\tau^j < \pi^j$. Consequently, gross investment in a specific country consists of net increases in both home-owned capital stock ($\pi^j I_t$) and foreign direct investment. Net exports are given by $nx_t^j = y_t^j - c_t^j - i_t^j$.

To understand why consumption demand shocks can help resolve the international comovement puzzles, I first illustrate how these puzzles can arise under technology shocks in the first place. Consider (country-specific) technology shocks (A^j) in the production functions: $y_t^j =$

[4] Note that although the next-period world capital stock (K_{t+1}) is known at time t, the next-period capital stock operating in a specific country, $k_{t+1}^j = \tau_{t+1}^j K_{t+1}$, cannot be determined in time period t because τ_{t+1}^j is not determined until period $t+1$.

$A_t^j \left(k_t^j\right)^{\alpha} \left(n_t^j\right)^{1-\alpha}$. The first-order conditions (7)-(10) can be rewritten (letting $\Delta^j = 0$ for $j = h, f$) as:

$$\frac{1}{c_t^h} = \frac{1}{c_t^f} \tag{11}$$

$$A_t^h \left(\tau_t\right)^{\alpha} \left(n_t^h\right)^{-\alpha-\gamma} = A_t^f \left(1-\tau_t\right)^{\alpha} \left(n_t^f\right)^{-\alpha-\gamma} \tag{12}$$

$$A_t^h \left(\tau_t\right)^{\alpha-1} \left(n_t^h\right)^{1-\alpha} = A_t^f \left(1-\tau_t\right)^{\alpha-1} \left(n_t^f\right)^{1-\alpha}, \tag{13}$$

where τ_t denotes the home-country's share of the world capital stock. These first-order conditions imply the following cross-country ratios:

$$\frac{c_t^h}{c_t^f} = 1 \tag{14}$$

$$\frac{y_t^h}{y_t^f} = \frac{\tau_t}{1-\tau_t} = \left(\frac{A_t^h}{A_t^f}\right)^{\frac{1+\gamma}{\gamma(1-\alpha)}} \tag{15}$$

$$\frac{n_t^h}{n_t^f} = \left(\frac{A_t^h}{A_t^f}\right)^{\frac{1}{\gamma(1-\alpha)}}. \tag{16}$$

These cross-country ratios indicate a perfect cross-country correlation for consumption and imperfect cross-country correlations for other variables such as output, investment, and labor (due to the assumption that technology shocks are country specific). In particular, since the world capital share τ_t is completely dictated by technology ratios across countries, the predicted cross-country correlations for output, investment, and labor are all negative under country specific technology shocks.[5]

Consider a positive technology shock in the home country. Consumption increases both at home and abroad because of an international income effect supported by the channel of transfer

[5] The cross-country ratios indicate that the volatilities of the model are very sensitive to the inverse labor supply elasticity parameter γ. As γ approaches zero, for example, even a very small technology shock can generate extremely volatile movements in output and labor due to factor mobility across countries. The volatility of factor mobility can be determined by log-linearizing equation (15), which gives

$$\left(\frac{1}{1-\tau}\right)\hat{\tau}_t = \frac{1+\gamma}{\gamma a(1-\alpha)}\left(\hat{A}_{ht} - \hat{A}_{ft}\right),$$

where circumflex variables denote percentage changes around the steady state. Assuming that country specific technology shocks have identical variances (σ_A^2) and are uncorrelated, we have

$$\sigma_\tau = \sqrt{2}(1-\tau)\frac{1+\gamma}{\gamma(1-\alpha)}\sigma_A.$$

For example, let the steady-state value of the world capital share $\tau = 0.5$, and let $\gamma = 0.25$ and $\alpha = 0.3$. We then have $\sigma_\tau \approx 5\sigma_A$. It is also clear that σ_τ approaches infinity as γ approaches zero.

of consumption goods. Employment increases at home and decreases abroad for two reasons. The first is an international substitution effect of leisure supported by risk sharing, which causes the high-productivity country to decrease leisure and the low-productivity country to increase leisure. This substitution effect exists regardless of capital mobility, as long as countries can trade in currently produced goods. The second reason is capital mobility, which permits existing capital to flow to the highest returns, thus increasing labor demand at home and decreasing labor demand abroad. Consequently, cross-country correlations for employment (as well as output) are negative. Investment increases at home and decreases in the foreign country also for two reasons. First, the ability to transfer investment goods across national borders induces national savings to flow to the highest expected returns. Second, capital mobility implies that the foreign direct investment is positive in the home country and negative in the foreign country (capital drain). Hence, general equilibrium theory predicts that cross-country correlations for output, employment, and investment are all negative under technology shocks unless these shocks are highly positively correlated across countries.

Thus puzzles arise: the predicted cross-country correlations are much higher for consumption than for output, while in the data the opposite is true; and the predicted cross-country correlations of employment and investment are negative, while in the data they are positive. Furthermore, the predicted volatilities for both investment and net exports relative to output are excessively large compared to the observed values.

There has been no shortage of explanations in the literature for these puzzles, with most of them focusing on market frictions and market incompleteness that inhibit international risk sharing. The problem is that some of these puzzles, especially the cross-country consumption correlations puzzle, are so robust to model modifications that none of the explanations advanced in the literature to date can completely resolve these puzzles at once (see footnote 2 for the literature).

However, the counter-factual predictions of the basic model are completely turned around if the primary source of shocks causing short-run economic fluctuations in international trade comes from the demand side (e.g., consumption) rather than from the supply side (e.g., technology). Under consumption demand shocks, the first-order conditions for the open economy imply the following cross-country ratios:

$$\frac{c_t^h - \Delta_t^h}{c_t^f - \Delta_t^f} = 1, \tag{17}$$

$$\frac{y_t^h}{y_t^f} = \frac{n_t^h}{n_t^f} = 1, \tag{18}$$

$$\frac{\tau_t}{1 - \tau_t} = 1. \tag{19}$$

The last equation implies that the optimal foreign direct investment (capital mobility) is zero (i.e., τ_t is constant).[6] Hence, we also have $\frac{i_t^h}{i_t^f} = 1$. These cross-country ratios imply that output, investment, and labor are perfectly synchronized across countries while consumption is imperfectly correlated across countries (due to country-specific demand shocks). Thus, unless consumption shocks are perfectly correlated across countries, the predicted cross-country correlations are higher for output than for consumption (as observed in the data); and the predicted cross-country correlations for employment and investment are positive (as observed in the data).

The intuition is simple. It is a typical Keynesian story of aggregate demand. Consider an increase in consumption demand in the home country due to a high urgency to consume. This raises demand for both domestic output and foreign output under international risk sharing. Hence production increases both at home and abroad in response to the higher world demand. In the mean time, investment may also rise both at home and abroad if the increase in demand is persistent, so that each country can build up more production capacities to sustain the persistent increases in the world demand. The higher investment demand across countries reinforces the initial rise in the world demand. Consequently, we observe strong comovements (positive correlations) in output, investment, and employment across countries. If the urge to consume (demand shock) is country-specific, consumption will be less correlated across countries than output.[7] Furthermore, since capital does not flow across borders, national savings rise mainly due to the increases in domestic investment demand, hence the predicted domestic saving-investment correlations are positive, as they are in the data.[8] In addition, given that τ_t does not respond to Δ_t, the predicted volatilities of investment and net exports are substantially lower than they are under technology shocks,[9] which resolves the extremely large export-volatility and investment-volatility puzzles identified by BKK (1992), without resorting to restrictions on capital mobility.

Notice that the results are not driven by the simplifying assumption of separability in the utility

[6] The intuition for τ_t being constant under demand shocks is that domestic investment possibilities offer a sufficient scope for self-insurance through intertemporal domestic reallocations when the two countries have identical technologies. Hence positive foreign direct investment is not optimal unless there are technology shocks which create differentials in returns to capital across countries.

[7] Risk sharing maximizes the cross-country correlations for $(c_t - \Delta_t)$, not for c_t.

[8] Under symmetric consumption demand shocks across countries, net exports of newly produced goods can be either positive or negative (with zero mean) and are not closely correlated with world investment (which is always positive). Hence,

$$Cov(s^j, i^j) = Cov(nx^j + I, I) = \sigma_I^2,$$

and

$$\sigma_s^2 = \sigma_{nx}^2 + \sigma_I^2,$$

for $j = h, f$. These imply

$$\rho(s^j, i^j) = \frac{\sigma_I}{\sigma_s} = \frac{\sigma_I}{\sqrt{\sigma_{nx}^2 + \sigma_I^2}} \in (0, 1).$$

It is clear then that the saving-investment correlation is not only positive but also close to one since the volatility of net exports is small relative to that of investment under persistent consumption shocks.

[9] When τ_t is constant, the volatility of investment for each country becomes the same as that of aggregate world investment.

function. What is crucial is that the preference shocks must truly represent shocks to consumption demand. Consider the non-separable utility function,

$$u(c_t, n_t) = \frac{\phi_t \left[(c_t - \Delta_t)^{\theta} (1 - n_t)^{1-\theta} \right]^{1-\sigma} - 1}{1 - \sigma},$$

where ϕ is a standard way to model preference shocks and Δ is the way adopted in this paper to represent shocks to the urge to consume. ϕ affects the marginal utilities of consumption and leisure in the same direction, while Δ affects them in the opposite direction. In a competitive equilibrium, the marginal rate of substitution is given by

$$\frac{\theta}{1-\theta} \frac{1 - n_t}{c_t - \Delta_t} = \frac{1}{w_t},$$

where w is the real wage taken as given by the agent. Clearly, ϕ dose not affect the marginal rate of substitution between consumption and leisure, but Δ does. This has important implications for the cross-country division of work. A positive ϕ-shock to the home country raises the marginal utility of both consumption and leisure at home relative to that of the foreign country, causing a decrease in labor supply at home and an increase in labor supply abroad due to international risk sharing. This leads to negative cross-country comovements in economic activities. On the other hand, although a positive Δ-shock increases the marginal utility of consumption at home, it also leads to an increase in hours worked. To see this, note that the increase in consumption is always smaller than the increase in Δ, otherwise the original consumption allocation before the shock would not have been optimal. Hence the term $c - \Delta$ decreases after the shock. According to the above equation, this implies that labor supply (n) at home will also increase so as to raise labor income to finance the higher consumption demand without crowding out savings. With trade, this also raises the net-exports demand in the foreign country, causing production to increase abroad. Hence Δ is a better representation for consumption demand shocks than ϕ in a traditional Keynesian sense when the utility function is nonseparable. If the utility function is separable, however, then it does not matter whether Δ affects the utility of consumption multiplicatively or additively, since the marginal utility of leisure is independent of Δ.

Table 1 reports cross-country correlations of output, consumption, investment, and employment predicted by the model when the utility parameter σ takes different values. The rest of the parameters are calibrated as follows: $\beta = 0.99, \alpha = 0.3, \delta = 0.025, \theta = 0.34$, and the steady state ratio, $\frac{\Delta}{c} = 0.1$.[10] The persistence of the consumption shocks is assumed to be 0.9 in an $AR(1)$ specification. It shows that country-specific consumption demand shocks always generate positive

[10] This ratio affects only the absolute volatility of the model, but has no effect on either the relative volatilities or the dynamics of the model. Hence it's calibration can be arbitrary.

cross-country correlations for economic activities in output, investment, and labor.[11] Hence, it does not matter whether the utility is separable or not between consumption and leisure. What is crucial is how the shocks enter the utility function.

Table 1. Sensitivity to Non-Separable Utility

σ	$corr(y^h, y^f)$	$corr(i^h, i^f)$	$corr(n^h, n^f)$
3	1.0	0.99	1.0
2	1.0	0.99	1.0
1	1.0	0.99	1.0
0	0.97	0.53	0.97

Thus, general equilibrium theory predicts that when urges to consume arise in a specific country, international trade (risk sharing) causes a world-wide production synchronization, which gives rise to the apparently puzzling phenomenon that "[w]hen an economic boom produces high output, employment, and investment in the United States, there is usually a simultaneous boom in other industrialized countries" (Baxter and Farr, 2005). This phenomenon is puzzling, however, only if we assume that international business cycles are driven primarily by technological differentials across countries. With consumption demand shocks as the main driving force of business cycles, the aforementioned phenomenon is expected and the international comovement "puzzle" disappears (at least in a qualitative sense).

3 The General Model

The basic model serves to demonstrate that consumption shocks can provide an alternative and effective way of resolving international comovement puzzles without resorting to extreme forms of market frictions. But the basic model has several shortcomings with respect to domestic comovements. First, labor productivity is countercyclical under consumption shocks in the basic model. To solve this problem, I follow the traditional literature by introducing factor hoarding – variable capital and labor utilization – into the basic model. Second, consumption is too volatile relative to output and investment under consumption shocks. To solve this problem, habit formation is introduced. The general model builds on the closed-economy model of Burnside and Eichenbaum (1996), Burnside, Eichenbaum, and Rebelo (1993) and Wen (2004, 2005).[12]

[11] The predicted cross-country correlation for consumption is close to zero but slightly negative. A little bit of positive cross-country correlation in the shocks can lead to positively correlated consumptions.

[12] For the recent literature on factor hoarding and procyclical productivity, see Basu (1996), Bernanke and Parkinson (1991), Dornbusch and Fischer (1981), Rotemberg and Summers (1990), and Shapiro (1993), among others. Habit formation has a long history in the study of consumption dynamics (see Deaton, 1992, for an overview). It has been used by Constantinides (1990), Abel (1990), Campbell and Cochrane (1999), Boldrin, Christiano and Fisher (2001), Wen (1998), and many others to explain asset markets dynamics and the business cycle. Wen (1998) also studies habit formation on leisure. Habit formation, however, can induce extremely smooth consumption and possibly countercyclical employment under technology shocks, as is shown recently by Lettau and Uhlig (2000). This problem, however, does not arise under preference shocks.

For simplicity, I continue to assume separability in preferences[13] and symmetry in technologies in the general two-country model. A planner in this world economy solves:

$$\max \sum_j \left\{ E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \begin{array}{c} \Delta_t^j \ln\left(c_t^j - bc_{t-1}^j\right) \\ +n_t^j \ln\left(T - \xi - \zeta e_t^j\right) + (1 - n_t^j) \ln T \end{array} \right\} \right\} \tag{20}$$

subject to

$$\sum_j c_t^j + \left[K_{t+1} - \left(1 - \sum_j \delta_t^j \tau_t^j\right) K_t\right] \leq \sum_j \left[\left(u_t^j \tau_t^j K_t\right)^{\alpha} \left(e_t^j n_t^j\right)^{1-\alpha} - \frac{\psi}{2}(n_t^j - n_{t-1}^j) K_t\right], \tag{21}$$

$$\sum_j \tau_t^j \leq 1, \tag{22}$$

and $K_0 > 0$ given for $j = h, f$; where $b \in [0, 1)$ measures the degree of habit, T denotes time endowment in each period, ξ is the cost of time from going to work, ζ is the length of working hours per shift, and e_t is the effort level. Following Burnside et al. (1993), labor supply is indivisible (e.g., Hansen, 1985; and Rogerson, 1988). Since the size of the labor force in each country is normalized to one, n_t represents the employment rate.[14] The parameter ψ measures the size of dynamic adjustment costs associated with changing employment relative to its previous level. Adjustment costs in employment give rise to an incentive for hoarding labor.[15] K_t in the adjustment cost term is a way to normalize the size of the adjustment costs in the steady state so that the parameter ψ can be calibrated more easily from data (see, e.g., Wen 2004); it has no effects on dynamic implications of the model near the steady state since it drops out from the model under a first-order Taylor expansion. Although adjusting employment stock is costly in the model, the effort level e (the utilization rate of labor) and the utilization rate of capital (u) can be adjusted instantaneously, reflecting the idea of factor hoarding (Burnside et al. 1993 and Burnside and Eichenbaum 1996). The rate of capital depreciation is time dependent and satisfies

$$\delta_t = \frac{1}{\phi} u_t^{\phi}, \quad \phi > 1,$$

[13] Hence the consumption shocks can be introduced in a multiplicative way, so as to avoid calibrating the steady-state ratio of $\frac{\Delta}{c}$ in the model.

[14] By assuming indivisible labor, this model does not have variable hours to work. The effort level, however, can be interpreted as a fraction of hours to work. The effective labor input in period t is $e_t n_t$. Under indivisible labor the utility function on leisure becomes linear. Thus, the marginal utility of leisure is constant and the labor supply curve is flat (infinitely elastic) and is hence not affected by preference shocks. Given a flat labor supply curve, equilibrium employment is determined solely by labor demand. Consequently, a preference shock has no direct effect on labor supply and it affects equilibrium employment only through influence on labor demand via changing the shadow price of goods (marginal utility of consumption). Hence, the indivisible labor specification helps legitimize the interpretation of preference shocks as genuine demand shocks.

[15] Wen (2004) shows that labor productivity is counter-cyclical in the model of Burnside at al. (1993) unless dynamic labor adjustment costs are allowed.

reflecting convex costs associated with the capital utilization rate (see Greenwood et al. 1988). K_t continues to denote the world capital stock and $\tau_t^j \in [0,1]$ the fraction of the world capital stock allocated to production in country j.

Denoting $\{\lambda, \mu\}$ as the multipliers for (22) and (23) respectively, the first-order conditions with respect to $\left\{c^j, n^j, e^j, u^j, \tau^j, K\right\}$ are given (ignoring second-order and higher terms) respectively by:

$$\frac{\Delta_t^j}{c_t^j - bc_{t-1}^j} - \beta b E_t \frac{\Delta_{t+1}^j}{c_{t+1}^j - bc_t^j} = \lambda_t, \tag{23}$$

$$\begin{aligned} & \log T - \log\left(T - \xi - \zeta e_t^j\right) - (1-\alpha)\lambda_t \left(u_t^j \tau_t^j K_t\right)^{\alpha} \left(e_t^j\right)^{1-\alpha} \left(n_t^j\right)^{-\alpha} \\ = \ & \beta\psi E_t \lambda_{t+1} \left(n_{t+1}^j - n_t^j\right) K_{t+1} - \psi\lambda_t \left(n_t^j - n_{t-1}^j\right) K_t, \end{aligned} \tag{24}$$

$$\frac{\zeta n_t^j}{T - \xi - \zeta e_t^j} = (1-\alpha)\lambda_t \left(u_t^j \tau_t^j K_t\right)^{\alpha} \left(e_t^j\right)^{-\alpha} \left(n_t^j\right)^{1-\alpha}, \tag{25}$$

$$\alpha \left(u_t^j\right)^{\alpha-1} \left(\tau_t^j K_t\right)^{\alpha} \left(e_t^j n_t^j\right)^{1-\alpha} = \left(u_t^j\right)^{\phi-1} \tau_t^j K_t, \tag{26}$$

$$\alpha \left(u_t^j K_t\right)^{\alpha} \left(e_t^j n_t^j\right)^{1-\alpha} \left(\tau_t^j\right)^{\alpha-1} - \frac{1}{\phi}\left(u_t^j\right)^{\phi} K_t = \mu_t, \tag{27}$$

$$\lambda_t = \beta E_t \left\{ \lambda_{t+1} \sum_{j=h,f} \left[\alpha \left(u_{t+1}^j \tau_{t+1}^j\right)^{\alpha} K_{t+1}^{\alpha-1} \left(e_{t+1}^j n_{t+1}^j\right)^{1-\alpha} + \frac{1}{2} - \frac{1}{\phi}\left(u_{t+1}^j\right)^{\phi} \right] \right\}, \tag{28}$$

for $j = h, f$.

It is worth noting that variable capital and labor utilization do not change the fact that the production technology has constant returns to scale. To see this, consider a simpler situation where the dynamic adjustment cost of employment is zero ($\psi = 0$). Then the first-order conditions with respect to effort (25) and employment (24) imply that if employment (n) is chosen contemporaneously with effort (e), then the optimal level of effort (e) in each country is a constant and is determined by the equation, $\log T - \log(T - \xi - \zeta e_t) = \frac{\zeta e_t}{T - \xi - \zeta e_t}$. Hence the output elasticity with respect to labor is always $(1-\alpha)$, not $2(1-\alpha)$. Since a positive ψ implies additional costs on changing employment, it does not enhance returns to scale in the model. With respect to capital utilization, it can be shown that the first order condition for the optimal utilization rate in each country, equation (4.7), implies $u_t = (\alpha)^{\frac{1}{\phi}} \left(\frac{y_t}{\tau_t K_t}\right)^{\frac{1}{\phi}}$, where y denotes output, which can be used to substitute out u in the original production function to obtain a reduced-form production function without capital utilization: $y_t = A(\tau_t K_t)^{\alpha\frac{\phi-1}{\phi-\alpha}} h_t^{(1-\alpha)\frac{\phi}{\phi-\alpha}}$, where $h_t \equiv e_t n_t$ is the effective labor service, and A is a constant. Clearly $\alpha\frac{\phi-1}{\phi-\alpha} + (1-\alpha)\frac{\phi}{\phi-\alpha} = 1$. Hence, variable capital utilization does not enhance returns to scale either; it simply enhances the output elasticity of labor service by reducing the output elasticity of capital (since $\frac{\phi}{\phi-\alpha} > 1$ and $\frac{\phi-1}{\phi-\alpha} < 1$).[16] Therefore, procyclical labor productivity in this model, if it arises, is completely due to labor hoarding and capacity utilization, not due to increasing returns or technology shocks.

Calibration. The time period is a quarter. I follow Burnside and Eichenbaum (1996) by setting $T = 1,369$ per quarter, $\xi = 60$, and $\zeta = 324.8$ (implying a steady-state effort level $\bar{e} = 1$). I also set the discounting factor $\beta = 0.99$, the capital's elasticity $\alpha = 0.3$, the steady-state quarterly rate of capital depreciation $\bar{\delta} = 0.025$ (implying a 10 percent rate of depreciation per year and $\phi \approx 1.4$), and the steady-state employment rate $\bar{n} = 0.94$ (implying an unemployment rate of 6 percent). These parameter values imply a steady-state capital-output ratio of 8.5 (in a quarter or 2.1 in a year) and a steady-state saving rate of 0.2. Based on Shapiro's (1986) estimates on the size of the adjustment costs of labor, Wen (2004) shows that $\psi = 0.5$ is roughly consistent with the U.S. data, implying a cost of approximately 0.1 percent of GDP. The habit-formation parameter b has been estimated by many people in the empirical literature and the results change depending on the instrumental variables used and whether monthly or quarterly data are used. According to Ferson and Constantinides (1991), the best point estimates of b using quarterly U.S. data lie between 0.95 and 0.97 with standard errors of 0.05 and 0.01 respectively. Using quarterly data from other industrial countries, Braun, Constantinides, and Ferson (1993) find point estimates of b of 0.82 (U.K.), 0.69 (France), 0.93 (Canada), 0.63 (Germany), and 0.64 (Japan), with relatively large standard errors. They also find that the log unity function is not rejected by most of these countries. More recently, Smets and Wouters (2003) give point estimates of b around 0.6 for European data. Hence, I will initially choose $b = 0.8$ as a benchmark for habit persistence, and then examine the robustness of my results against different values of b.

In order to make sure that the results are not driven by the assumption of capital mobility in the general model, a transportation cost for shipping capital across boarders is also introduced. The literature has shown that restricting international capital mobility either by transportation costs (Obstfeld and Rogoff, 2000) or by capital adjustment costs (Pakko, 2003) can help resolve some of the counter-factual predictions of technology shocks. Although it is shown here that replacing technology shocks by consumption demand shocks can resolve the international comovement puzzles without introducing frictions to hinder capital movement, it is better still that the resolution offered by demand shocks can withstand such frictions. To allow for the possibility of capital immobility in

[16] See Wen (1998) for more discussions on the dynamic effects of capital utilization.

the model, assume there exist transport costs associated with shipping fixed capital across borders. The cost function is given by:

$$\frac{\theta}{2}\left(\tau_t - \tau\right)^2 K_t,$$

which implies that the marginal transport cost is proportional to the size of foreign direct investment.[17] The parameter θ thus determines the degree of capital mobility.

Since consumption shocks and technology shocks give exactly opposite predictions for the cross-country correlations, and since the data lie somewhere in between quantitatively, it is therefore interesting to evaluate the relative importance of the two types of shocks in the model for explaining the data. For this purpose, I also add country-specific independent technology shocks into the model so as to see what magnitude of technology shocks is needed in the model in order to bring the predicted cross-country correlations into closer conformity with the data quantitatively. Country specific technology shocks are introduced via the production technology: $y_t = A_t(u_t\tau_t K_t)^{\alpha}(e_t n_t)^{1-\alpha}$. It is assumed that all exogenous shocks in the model follow random walks:

$$\begin{pmatrix} \log \Delta_t^h \\ \log \Delta_t^f \\ \log A_t^h \\ \log A_t^f \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \log \Delta_{t-1}^h \\ \log \Delta_{t-1}^f \\ \log A_{t-1}^h \\ \log A_{t-1}^f \end{pmatrix} + \begin{pmatrix} \varepsilon_{\Delta t}^h \\ \varepsilon_{\Delta t}^f \\ \varepsilon_{At}^h \\ \varepsilon_{At}^f \end{pmatrix},$$

where innovations in technology and preference shocks are assumed to be independent, $corr(\varepsilon_A, \varepsilon_\Delta) = 0$. The correlation between technology shocks, $corr(\varepsilon_A^h, \varepsilon_A^f)$, is estimated by Baxter and Farr (2005) as 0.258. This is also the value assumed here. There is no direct empirical evidence to calibrate the variances of $\{\varepsilon_\Delta^h, \varepsilon_\Delta^f\}$. In this paper, I assume symmetry across countries and calibrate the variance of the demand innovations such that the model generates an output volatility exactly the same as its U.S. counter part. I also assume that $corr(\varepsilon_\Delta^h, \varepsilon_\Delta^f) = corr(\varepsilon_A^h, \varepsilon_A^f)$.[18] The standard deviation of the technology innovation, σ_{ε_A}, is a free parameter to be chosen such that the model can best match the data with respect to cross-country comovements, given the variances and covariances of consumption shocks. Then I can compute the ratio of the variances of output with and without the technology shocks. This provides an informal measure of the relative importance of consumption shocks for explaining output volatility.

[17] An alternative restriction is that τ_t must be determined one period in advance. Under this restriction, τ_t cannot respond to shocks in time period t but τ_{t+1} will respond if the shocks are expected to be persistent. The results are similar.

[18] None of the predicted cross-country correlations of the model depends on the choice of this value, except the correlation of consumption.

Table 2. Predicted Moments (standard errors in parentheses)*

	Data	Model ($\sigma_A^2 = 0$)	Model ($\sigma_A^2 > 0$)	Model ($\theta = .35$)
International				
$\rho(y^h, y^f)$	0.81^a – 0.51^b	1.00 (0.0)	0.99 (0.0)	0.59 (0.2)
$\rho(c^h, c^f)$	0.67^a – 0.32^b	0.04 (0.3)	0.05 (0.3)	0.05 (0.3)
$\rho(i^h, i^f)$	0.73^a – 0.29^b	1.00 (0.0)	0.35 (0.2)	0.35 (0.2)
$\rho(n^h, n^f)$	0.75^a – 0.43^b	1.00 (0.0)	0.99 (0.0)	0.63 (0.2)
$\rho(y/n, y/n)$	0.56^e – 0.16^f	1.00 (0.0)	0.99 (0.0)	0.52 (0.1)
Domestic				
$\rho(c, y)$	0.87^b – 0.81^a	0.70 (0.1)	0.71 (0.1)	0.63 (0.2)
$\rho(i, y)$	0.93^b – 0.81^a	0.95 (0.0)	0.80 (0.1)	0.95 (0.0)
$\rho(n, y)$	0.86^b – 0.78^a	0.86 (0.0)	0.86 (0.0)	0.84 (0.1)
$\rho(y/n, y)$	0.87^a – 0.68^f	0.58 (0.1)	0.58 (0.1)	0.63 (0.1)
$\rho(s, i)$	0.94^c – 0.68^d	0.77 (0.1)	0.68 (0.1)	0.87 (0.1)
$\rho(nx/y, y)$	-0.36^b – -0.66^d	-0.92 (0.0)	-0.88 (0.1)	-0.94 (0.0)
Volatility				
$\sigma_y(\%)$	1.69^a – 1.71^d	1.69 (0.0)	1.70 (0.0)	1.95 (0.0)
$\tilde{\sigma}_y(\%)$	n/a	1.69 (0.0)	1.69 (0.0)	1.69 (0.0)
σ_c/σ_y	0.76^a – 0.79^b	0.88 (0.2)	0.88 (0.1)	0.76 (0.1)
σ_i/σ_y	2.98^a – 3.27^e	2.91 (0.1)	3.56 (0.5)	3.21 (0.2)
σ_n/σ_y	0.85^a – 0.63^b	0.81 (0.1)	0.81 (0.1)	0.78 (0.1)
$\sigma_{y/n}/\sigma_y$	0.59^a	0.51 (0.1)	0.52 (0.1)	0.54 (0.1)
$\sigma_{nx/y}/\sigma_y$	0.25^a – 0.86^a	0.46 (0.1)	0.59 (0.2)	0.38 (0.1)
Persistence				
$\rho(y_t, y_{t-1})$	0.89^a – 0.85^d	0.81 (0.1)	0.81 (0.1)	0.77 (0.1)

*Note: The predicted statistics are based on 500 simulations with sample length of 100. All series are H-P filtered. Data source: a: Baxter and Farr (2001); b: Kehoe and Perri (2002); c: Feldstein and Horioka (1980); d: BKK (1992); e: BKK (1995); f: Ambler et al. (2004).

Table 2 reports the predicted moments of the model along with the estimated data moments (in the second column) reported by the existing literature.[19] The third column reports the predictions of the model with consumption shocks only (i.e., $\sigma_A = 0$), where the standard deviations of consumption shocks are chosen such that the predicted output volatility (σ_y) matches the data. This gives $\sigma_\Delta = 0.025$.[20] The predicted moments confirm the previous analysis in Section 2 that

[19] In Table 2, σ_y represents the standard deviation of output and $\tilde{\sigma}_y$ represents the standard deviation of output in the absence of technology shocks. The estimated data moments reported by the existing literature vary quite a lot depending on the particular countries and sample periods selected as well as on the specific definitions of variables adopted. For example, the estimated cross-country correlations for output range from 0.81 (reported by Baxter and Farr, 2001) to 0.51 (reported by Kehoe and Perri, 2000) or even much lower (reported by Backus, Kehoe and Kydland, 1992), and the reported cross-country correlations for consumption range from 0.67 (reported by Baxter and Farr, 2001) to 0.32 (reported by Kehoe and Perri, 2000) or even negative (reported by Backus, Kehoe and Kydland, 1992). What remain as robust features of the data, therefore, are not the quantitative but qualitative characteristics; namely, the cross country correlations are positive and significantly higher for output than for consumption, and they are positive for hours and investment. Similar caveats apply to statistics characterizing domestic business cycles.

[20] This number can be reduced substantially if the consumption shocks enter the utility additively: $u(c, \Delta) = \log(c - \Delta)$; provided that the steady-state ratio, $\frac{\Delta}{c} \in [0, 1]$, is not too small. This ratio will not affect the relative volatilities of the model variables, nor the dynamics of the model.

consumption shocks can qualitatively explain the positive international comovements. The fourth column reports the predicted moments when technology shocks are added into the model. The standard deviation of technology shocks is increased until the point beyond which the cross-country correlation for investment becomes insignificant or negative. This gives $\frac{\sigma_A}{\sigma_\Delta} = 0.0005$, which provides an informal measure of the relative importance of technology shocks. With this proportionality, the contribution of technology shocks to the total variance of output is less than one percent, as can be seen in the table by comparing $\tilde{\sigma}_y$ (the volatility of output in the absence of technology shocks) with σ_y. The last column reports the case when capital mobility is restricted, $\theta = 0.35$, and when $\frac{\sigma_A}{\sigma_\Delta} = 0.08$. The value of θ implies that the marginal cost of shipping capital across borders is about 35% of foreign direct investment. Allowing for such a cost value in capital mobility increases the relative importance of technology shocks in the model substantially, since it reduces the negative impact of technology shocks on international comovements and hence the tolerance of technology shocks in the model. As a consequence, the model's predicted moments can also be brought closer to the data quantitatively. In this case, the relative standard deviation of technology shocks can be increased to a value as high as $\frac{\sigma_A}{\sigma_\Delta} = 0.1$ before the predicted cross-country correlations become insignificant or negative. However, under this volatility ratio, consumption shocks still explain more than 80 percent of the variance of the U.S. output. In the extreme case where $\theta = \infty$, so that capital is completely immobile, only less than 30% of output variance can be attributed to technology shocks without causing counter-factual predictions for cross-country correlations. These results suggest that consumption shocks must play a dominant role in order for the model to explain the data well. This also explains why Stockman and Tesar (1995) fail to completely resolve the international comovement puzzles by adding preference shocks, since they allow technology shocks to play a dominant role in their model.

Overall, regardless of capital mobility and technology shocks, the predictions of the model are qualitatively consistent with the data, although adding technology shocks and at the same time restricting capital mobility can improve the model's predictions quantitatively. In particular, the top panel of Table 2 (last column) shows that the predicted cross-country correlations are positive for output (y), investment (i), employment (n) and productivity (y/n); and the correlations are higher for output than for consumption and productivity. These predictions are consistent with the data (see, e.g., BKK, 1992, 1995). With regard to domestic comovements, the middle panel shows that productivity, consumption, investment, and employment are all positively correlated with output, and the net exports-to-output ratio (nx/y) is negatively correlated with output, as in the data. Consistent with the data, the predicted correlations between domestic saving rates and investment rates are strongly positive, consistent with the empirical findings of Feldstein and Horioka (1980). The lower panel shows that predicted domestic output is less volatile than investment but more volatile than consumption and the net exports-to-output ratio. Furthermore, the predicted output is strongly serially correlated (the bottom panel). These predictions are also consistent with the data (Kydland and Prescott, 1982; and BKK, 1992). The weakest aspect of the model is perhaps the extremely weak cross-country correlation for consumption. Unless a strong cross-country correlation of consumption innovations is assumed, the model is not able to match the data in this aspect.

Intuition. Impulse-response analysis is always useful for understanding the intuitions. In order to generate trend-reverting impulse responses, I change the AR(1) coefficient of the shocks to 0.95. Figure 1 shows the impulse responses of labor productivity, output, consumption, employment, and investment in the two-country model to a home consumption shock. Several features of the model are worth noticing. First, productivity increases persistently both at home and abroad, indicating that demand shocks can generate procyclical productivity not only at home but also abroad. Second, all variables in the home country are strongly positively correlated with each other, showing that demand shocks are just as capable of explaining the domestic business cycle comovements as technology shocks. Third, except consumption, all variables are positively correlated with their counterparts in the foreign country, showing strong international synchronization of economic activities under the Keynesian "demand-pull" effect of consumption shocks. This also implies that the cross-country correlations are higher for output than for consumption. Fourth, output is hump-shaped both at home and abroad, indicating a richer propagation mechanism in the model than in standard RBC models (e.g., BKK 1992). This richer propagation mechanism is mainly attributable to the adjustment costs of employment, which is also crucial for generating the procyclical productivity.

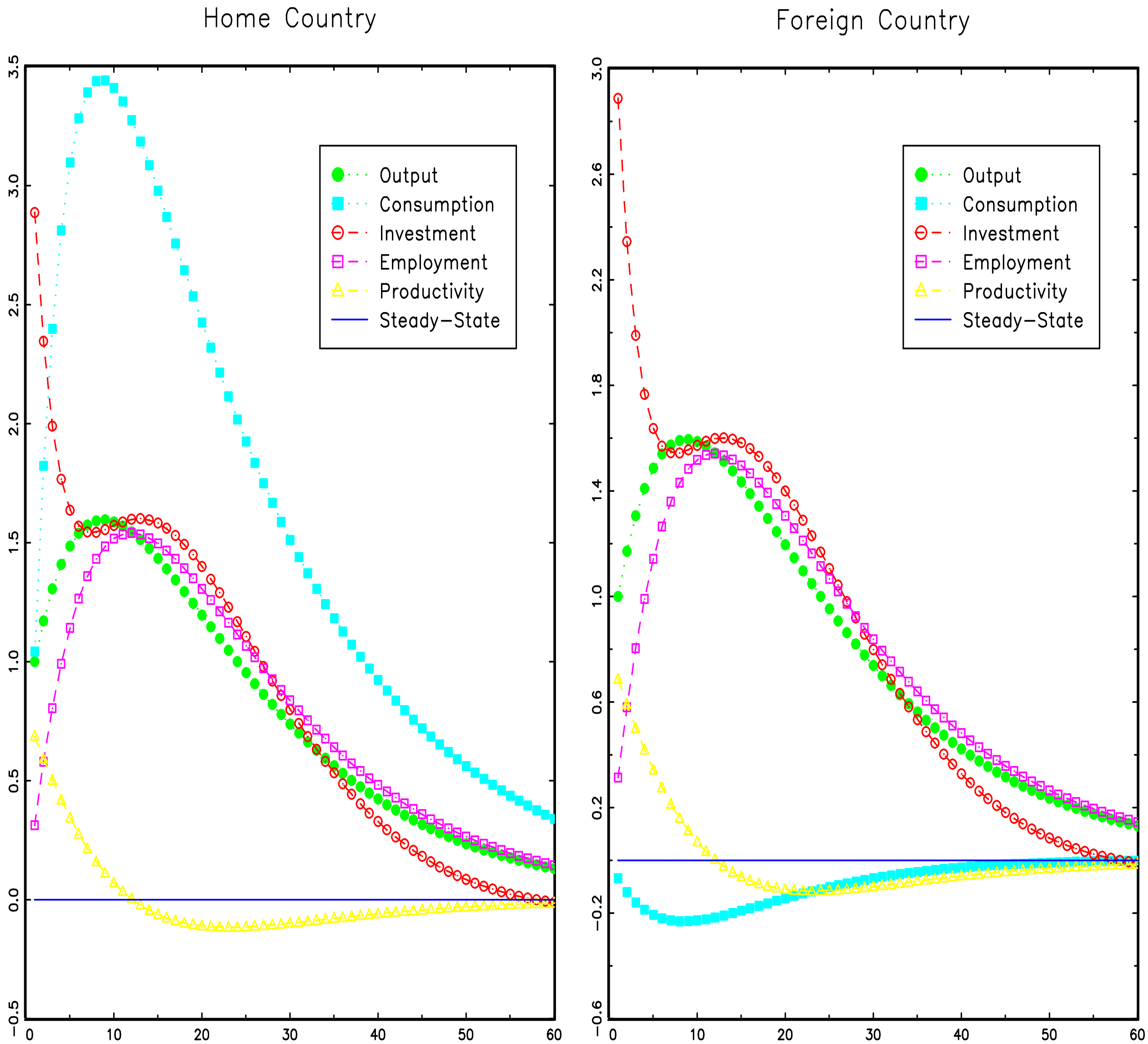

Figure 1. Impulse Responses to a Home Consumption Shock.

Under a home-technology shock, on the other hand, productivity, output, employment, and investment increase in the home country but decrease in the foreign country, indicating negative cross-country correlations for these variables. In the meantime consumption increases both at home and abroad, suggesting higher cross-country correlations for consumption than output. These predictions are inconsistent with the data.[21] However, quantitatively speaking, since the data lie somewhere in between the predictions of consumption shocks and technology shocks, a combination

[21] To preserve space, the results are not reported here. But they can be found in my working paper (Wen, 2002). This counter-factual implication of technology shocks indicates that the results obtained by Baxter and Farr (2005) are not robust. They claim that variable capacity utilization can resolve the international comovements puzzles under random walk technology shocks. My results show that technology shocks still generate counter-factual predictions regarding international comovements even with variable capacity utilization and labor hoarding.

of both shocks can bring the model into closer conformity with the data, especially when frictions of capital mobility are present so that the strongly negative effects of home-technology shocks on foreign investment can be mitigated.

The analysis clearly shows that economic booms/recessions in one country can lead to simultaneous booms/recessions in another country when the fluctuations are driven by aggregate demand. This international transmission of the business cycle under the demand-pull effect offers an explanation for the strong economic recovery of the Japanese economy in the last couple of years due to the strong export demand from China. Thus, the prolonged productivity slowdown and output stagnation in Japan for the entire 1990s may not necessarily be due to slower technology growth, but could be due to insufficient aggregate demand after the burst of the Japanese housing bubble in the early 1990s.

Robustness. As explained previously, in order to generate sufficiently smooth consumption and sufficiently volatile and procyclical domestic investment within each country, preference shocks need to be highly persistent. Under the assumption of random-walk preference shocks, the model is able to generate sufficiently volatile and procyclical investment. However, consumption is still not smooth enough to match the data. The assumption of habit formation is helpful in reducing the consumption volatility. Table 3 reports a sensitivity analysis on the model's predictions with regard to the habit formation parameter, b. Since the effects of habit formation on international comovements are minimal, the focus is on the volatility of domestic consumption and investment, and investment's correlation to GDP (in the absence of technology shocks). Table 3 confirms that the role of habit formation is mainly to reduce the consumption volatility to an empirically plausible level with regard to the U.S. data. With respect to investment dynamics, habit formation is not needed.[22]

Table 3. Sensitivity to Habit Persistence (standard errors in parentheses)*

b	0	0.3	0.5	0.7	0.9	0.95
σ_c/σ_y	1.37 (0.2)	1.24 (0.2)	1.16 (0.2)	1.00 (0.2)	0.68 (0.1)	0.54 (0.1)
σ_i/σ_y	2.01 (0.1)	1.98 (0.1)	2.13 (0.1)	2.52 (0.1)	3.47 (0.1)	3.80 (0.1)
$\rho(i,y)$	0.86 (0.0)	0.95 (0.0)	0.97 (0.0)	0.96 (0.0)	0.96 (0.0)	0.96 (0.0)

*Note: The predicted statistics are based on 500 simulations with sample length of 100. All series are H-P filtered.

4 Conclusion

This paper studies the potential role of demand shocks in explaining the observed international synchronization of economic activities. It is shown that increases in consumption demand can stimulate output and productivity domestically, which raises economic activity in other countries

[22] In the U.S., non-durable goods consumption is always less volatile than output. However, this is not always the case for some European countries. In this regard, the assumption of habit formation is not even necessary for explaining consumption in certain European countries.

as well through net export demand. This demand-side effect is reminiscent of traditional Keynesian theory, yet without assuming sticky prices (in contrast to the textbook IS-LM models for both closed and open economies). It is also shown that the observed cross-country synchronizations in productivity do not have to be explained by assuming highly correlated technology shocks across borders. Country-specific demand shocks can also explain the procyclical and correlated productivity movements across nations. This prediction is consistent with the most recent economic revival of the Japanese economy, which is largely driven by net-exports demand from China.

However, several important issues remain for further investigation. First, in order to overcome the crowding-out problem, consumption shocks either have to be highly persistent, or there must exist strong habit formation. Otherwise, domestic investment may be counter-cyclical with respect to domestic output and consumption may not be smooth enough in the model (see Wen 2002 and 2005 for more detailed analysis). Second, how to measure consumption demand shocks in the data remains a challenge for any theory that advocates demand shocks as the major driving force of the business cycle. This problem does not arise in partial equilibrium models studying firms' behavior, where consumption demand can be taken as exogenously given. In general equilibrium models, though, consumption is endogenous, so shocks to consumption demand can only come from preference changes or changes in consumers' forecast of the future. Such changes, however, are not observable. In addition, such aggregate shocks require that there be a coordination device among individuals. This is difficult to model in a representative-agent framework.[23] Lastly, the literature has documented that the seasonal cycle displays very similar characteristics to that of the business cycle (e.g., Barsky and Miron, 1989; Miron and Beaulieu, 1996). Since seasonal fluctuations are primarily driven by consumption spending at Christmas, there is a possibility of a unifying theory of seasonal and business cycles. This possibility is beyond the scope of the paper and is left for future investigation.

[23] See Nakajima (2005) for a different approach.

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